DECEMBER 2015 **P/ID 40005/PPHE**

Time : Three hours Maximum : 100 marks

PART A — (10 × 2 = 20 marks)

Answer ALL questions.

1. Define differential and total cross sections.

2. Write the general form of scattered wave function.

3. What do you mean by adiabatic perturbation?

4. What are density operator and density matrix?

5. Write two inadequacies of Klein–Gordon equation.

6. Write the names of two particles obeying Dirac equation.

7. What do you mean by Lorentz covariance of an equation.

8. Write any two properties of gamma matrices.

9. Define the terms first quantization and second quantization.

10. State the effects of creation and annihilation operators on the state K of a field.

PART B — (5 × 6 = 30 marks)

Answer ALL questions.

11. (a) Obtain the formula for scattering amplitude by Born approximation.

Or

(b) In a scattering process the wave function is $e^{iKZ} + \frac{\cos\theta}{10}\frac{e^{iKr}}{r}$. Calculate the total scattering cross-section.

12. (a) If ρ is the density operator prove that $Tr(\rho) = 1$ and $Tr(\rho^2) = 1$.

Or

(b) The perturbation $V(t) = e^{at}$, $0 < a << 1$ is switched on at $t = -\infty$ and the initial state of the system is p_i. Determine the probability amplitude of finding the system in the f^{th} state at time t.

13. (a) Obtain the Klein–Gordon equation.

Or

(b) Write a note on negative energy states.

14. (a) Show that Dirac equation can be given as

$$\left(S^{-1}r_{\mu}S\frac{\partial}{\partial x_{\mu}}+\frac{MC}{\hbar}\right)S^{-1}\psi=0\,.$$

Or

(b) Setup the Dirac equation in covariant form.

15. (a) Write the commutation relations for the Klein-Gordon fields ψ and π and creation and annihilation operators.

Or

(b) Write the Hamiltonian of electromagnetic field in terms of creation and annihilation operators.

PART C — (5 × 10 = 50 marks)

Answer ALL questions.

16. (a) With potential $V(r)=-\frac{Ze^2}{r}e^{-r/a}$, obtain the scattering amplitude in Born's approximation.

Or

(b) Establish the connection between scattering cross-sections in centre of mass and laboratory frame of reference systems.

17. (a) Develop a perturbation theory applicable for harmonic perturbation.

Or

(b) For an atom is an oscillating electric field obtain an expression for transition amplitude.

18. (a) Prove that the Dirac theory requires a spin magnetic moment.

Or

(b) Determine the energy values of a Dirac particle in a coulomb potential.

19. (a) Discuss about the relativisitc invariance of the Dirac equation.

Or

(b) Setup the Dirac equation for an electron in a field and show that it is invariant under the gauge transformation $A_K = A'_K + \frac{\partial X}{\partial x_K}$ where X is an arbitrary function and $\psi = \psi' \exp[ieX/\hbar C]$.

20. (a) Obtain the equation of motion for the real field ψ of Klein-Gordon equation.

Or

(b) For the electromagnetic field in vacuum show that $\left[\vec{A}, \pi^2\right] = 2\, i\, \hbar\, \delta^3(\vec{r} - \vec{r}')\, \pi'$.
